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Morrison TRAILBLAZER

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
EQUIPMENT DEVELOPMENT CENTER
MISSOULA, MONTANA

EVALUATION OF THE MORRISON TRAILBLAZER

APRIL 1970

U. S. Department of Agriculture
Forest Service
Equipment Development Center
Missoula, Montana

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NOTE

Copies of photos contained in this report may be obtained from the Equipment Development Center, Missoula, Montana 59801.

ABSTRACT

The Center tested the Morrison Trailblazer, a small, tracked backhoe that is designed for building 24-inch-wide trails. The evaluation included performance and static stability tests as well as operation and maintenance procedures. A section of trail was built in mountainous terrain, and costs were compared with estimates based on use of handtools. Test results indicated use of the Trailblazer can reduce costs of building trails 40 to 50 percent, compared to using handtools. Operators must be carefully selected and trained and proper maintenance adhered to.

CONTENTS

ILLUSTRATIONS

TABLES

INTRODUCTION

One of the most important tasks in managing the National Forest System is building and maintaining trails. There are more than 100,000 miles of trails in the National Forests. In 1968, the Forest Service spent $4.5 million constructing new trails. The amount spent annually does not reflect the size of the job that needs to be done. An accurate appraisal is reflected in the Transportation Inventory Record of 1967. This report states that of the 100,000 miles of trails in existence, about 48 percent are considered to be below standard for the use intended and an additional 22,000 miles should be built to complete the transportation plan.

Based on current construction methods and reliance on hand labor, it would cost about $122 million ($2,500 per mile) to bring the existing trails up to standard, and about $128 million ($5,830 per mile) to construct the new trails.

Faced with a trail construction and reconstruction job of this size, the Washington Office Division of Engineering has assigned this Center the job of developing and testing machines to build and maintain trails. This report covers project ED&T 1943, Evaluation of the Morrison Trailblazer, a small, tracked backhoe specifically designed for building trails as narrow as 24 inches. The machine is manufactured by the Nelson Equipment Co., Portland, Oregon.

TRAILBLAZER DESCRIPTION

The Trailblazer is a scaled-down track-driven backhoe with limited dozing capabilities (fig.1). It is powered by a 16.8 hp Wisconsin engine that operates a two-stage hydraulic pump. One stage of the hydraulic system transmits power to the tracks, the other provides power for the backhoe and dozer blade. Overall width of the machine is 24 inches. An optional feature is an adjustment that allows each track to be moved outward 3 inches. Overall width in this configuration is 30 inches (figs. 2 and 3).

Figure 1. – Side view of Trailblazer

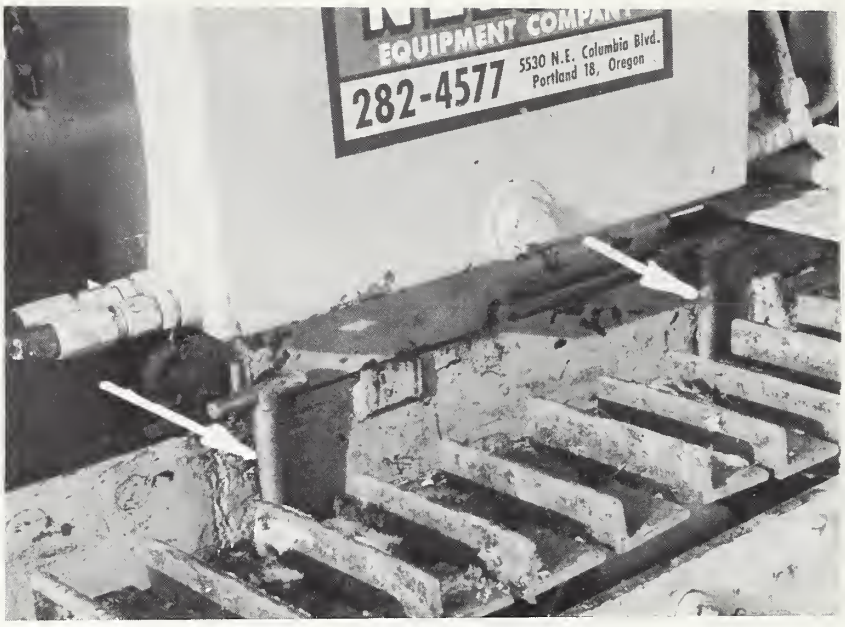

Figure 2. — Pins for adjusting track width.

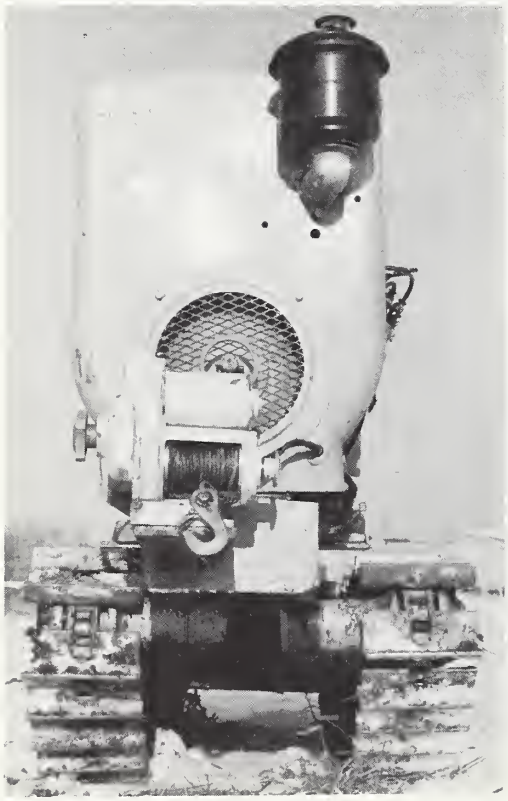

Figure 3. — Left track in standard position, right track extended 3 inches.

The Trailblazer can be transported in a pickup truck (fig. 4) without alteration. The machine also can be rapidly disassembled into five major components for helicopter transport. Maximum travel speed for the Trailblazer is 2 mph, so transport by helicopter may often be required for long travel distances.

The blade is raised, lowered, and tilted hydraulically. Angling the blade is done mechanically by pulling and repositioning one pin. The blade has three positions—straight, or angled 15° to either side. The backhoe is a conventional system and all functions are hydraulically controlled. There are two attachments available, a grubhoe (fig. 5) designed to speed trail construction in light and medium soils with brushy cover, and a bucket attachment for digging. The mounting angle of the bucket is basically different from the backhoe, and a smaller cylinder is used to increase travel speed of the bucket.

When used for trenching and ditching, the Trailblazer is capable of excavating a 12-inch-wide trench up to 42 inches deep. Another optional feature is an electric winch that has a manufacturer's rated capacity of 2,500 pounds. Fifty feet of 3/16-inch cable is supplied with the winch. Shipping weight of the Trailblazer is 2,250 pounds. This includes grubhoe attachment and the winch. The Trailblazer in operation weighs approximately 2,000 pounds.

Figure 4. — Trailblazer transported in pickup truck.

Figure 5. — Grubhoe attachment.

The basic machine price, as of August 1969, is $5,450 f.o.b. Portland, Ore., and includes backhoe and bucket. Accessory prices are: Grubhoe $395, winch $133, and extendable track $200. Quotes should be solicited for each purchase from the manufacturer, Nelson Equipment Company, 5530 N. E. Columbia Blvd., Portland, Ore. 97220.

TEST PROCEDURE

Field Test

Field tests were conducted in Wrangle Creek in the Rattlesnake drainage, approximately 25 miles north of Missoula. Most of the construction conditions at the site were classified as medium or heavy. Sideslopes varied between zero and 80 percent, as commonly found on trail construction sites. Grading classifications on these slopes would fall into the following four categories:

Heavy Grading.—Includes heavy duff or bear grass, many roots and rocks. Rocks and roots vary in size and are on or below the surface.

Medium Grading.—Intermittent conditions defined in heavy grading classifications, with roots smaller than 2 inches in diameter and rocks under 30 pounds.

Medium-Light Grading.—Soil practically free of duff, roots, rocks, and other obstructions.

Light Grading.—Less than 5 percent sideslopes and very little backhoe work required. Blade can be effectively used in this grading classification.

Results

Table 1 illustrates the time required to excavate tread with the Trailblazer for the various grading conditions.

Table 1.—Production rates for the Morrison Trailblazer for various grading classifications

Grading classification	Hours of operation	Feet constructed	Feet per hour
Light	3	626	209
Medium-Light	17	1,548	91
Medium	60	3,806	64
Heavy	62	2,770	45
Total	142	8,750	Average: 62

During the performance test, 7,750 feet of new trail was 90 percent completed, an additional 1,000 feet was 75 percent completed, 12 switchbacks were constructed, and one 20-foot native timber bridge was built. Mud holes created in the trail by heavy rains could not be corrected during the test period. This resulted in the 7,750 feet being only 90 percent finished. Finishing the remaining 1,000 feet would have required blowing a few stumps, chopping out small roots, and doing some hand work.

The crew consisted of four men. Three cleared brush, blasted stumps, and did other hand labor. The fourth man operated the Trailblazer during the entire test. Because clearing and grading were started concurrently, the Trailblazer had to be shut down for short periods while clearing work was accomplished. The machine averaged 5 productive hours of work within a regular 8-hour day. Camp was located at the beginning of the project, and scooters were used for traveling so productive time would not be lost in travel. Expenditures for the project are shown in Table 2.

Table 2.—Expenditures on Wrangle Creek Project

Nonexpendable Camp Supplies	$265.00		Per Diem (Meals)(Operator)	$ 269.53
Expendable Supplies		$ 425.00	C&M Foreman's Salary	121.00
Bridge Supplies		160.00	District and Forest Overhead	312.00
Laborer's Wages		2,928.00	Annual Leave	187.00
Per Diem (Meals)(Laborers)		728.00	Transportation	66.00
Operator's Wages		1,329.00		
Total	$265.00			$6,523.53

Based on a 7-year life, a reasonable hourly rate for use of the Trailblazer would be $4.32 (Appendix A). If nonexpendable camp equipment (tent, stove, lantern, etc.) is depreciated over 3 years, it would cost $8,150 (.93/foot) to build the 8,750 feet of trail on Wrangle Creek. This would represent a cost of $4,920 per mile. District personnel estimated that using hand methods the same section of trail would cost $10,000 per mile. Thus use of the Trailblazer would effect a savings of approximately 50 percent.

Static Stability Test

This test was conducted to determine stability limits. Tilt angles were measured under static conditions. These angles can be used to find the location of the vertical center of gravity. The tilt angle is the maximum angle the machine will tilt before tipping. The angle will decrease under dynamic conditions where backhoe operating forces can introduce momentum.

Results

Table 3 illustrates the results gathered from this test and shows that the vertical CG location does not change as the track width varies until the weight of the backhoe introduces a moment which acts above the CG location of the machine. The table also illustrates why the bucket should be worked in front of the machine rather than to the side.

Table 3.–Trailblazer static stability limits

BACKHOE POSITION					
Boom and Stick	Swing	Height of Bucket Above Ground	Track Width (Inches)	Angle of Tilt	Location of Vertical CG (Inches)
Extended	Forward	4 inches	30	41°	17.16
			24	35°	17.16
Extended	Forward	65½ inches	30	38°	19.19
			24	33°	18.47
Extended	Full right or left	55½ inches	30	32°	24.0
			24	23°	28.27

The tilt test was repeated to measure the force required to cause a tip-over. The boom, stick, and bucket were fully extended for this test, and the force was applied to the bucket teeth. Table 4 shows the results of this test.

Table 4.–Forces required to tip the Trailblazer with boom, stick and bucket fully extended

Swing Position	Track Width	Dozer Position	Force-Pounds
Full left or right	30 inches	Up	275
	30 inches	Down	300
	24 inches	Up	150
	24 inches	Down	230
Forward	24 and 30 inches	Up	350*
	24 and 30 inches	Down	Greater than 1000*

*Nosed over forward.

Further testing indicated that the boom can lift 550 pounds, and that the stick can lift 1,000 pounds when the hydraulic system relief valve is set at 1200 psi as recommended by the manufacturer. Table 4 shows that a full bucket of dirt can be lifted to any position without introducing instability. The table also shows how stability is improved by keeping the blade firmly on the ground while operating the backhoe.

Figure 6 illustrates the capability of the Trailblazer to remain stable with a 190-pound man standing on the bucket positioned to exert the maximum unbalanced tipping moment.

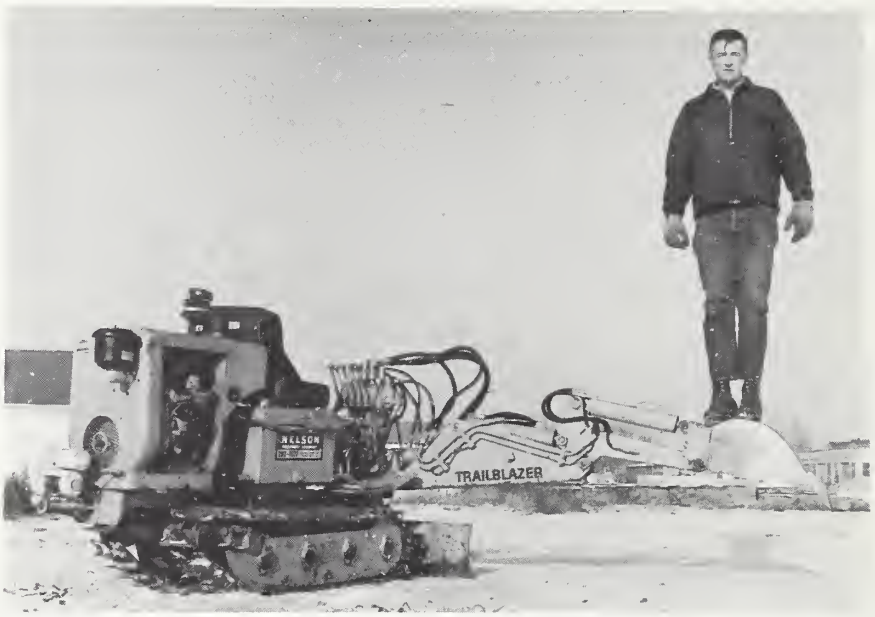

Figure 6. — A 190-lb man standing on bucket that is positioned to exert maximum unbalanced tipping moment.

In 1967, Lee Corbin, trail coordinator in Region 6, compared costs of building trail by hand and costs of building trail with the Morrison Trailblazer. Of 155.47 miles of trail built in the Region that year, 63.17 miles were built by hand at a cost of $8,829.93 per mile, and 92.3 miles were built using the Trailblazer at a cost of $4,603.37 per mile. Trail constructed with the Trailblazer cost 48 percent less than trail by hand.

OPERATION AND MAINTENANCE

Selecting and Training Operators

Successful use of the Trailblazer requires competent and capable operators. In general, a person with a mechanical background and an interest in machinery makes a good candidate. Individuals who are skilled in handling farm machinery can easily become proficient in the operation of the machine. Our experience indicates that experienced heavy equipment operators are poor candidates because they tend to be dissatisfied with the reduced production rates.

As an individual is learning to operate the Trailblazer, the trail manager should pay close attention to the following details:

Tip-Overs.—If the operator has trouble stabilizing the machine and is occasionally tipping it over, likely he is not proficient in machine operation.

Increased Production.—With experience, the operator should gain confidence in the machine and in his own ability. By the end of 5 days of operation he should be producing 300 feet of excavated tread per day. (One day equals an 8-hour work period or 5 machine hours.)

Breakdowns.—If breakdowns are frequent, and especially if the same parts fail repeatedly, likely the machine is not being operated within its design limits.

Modifications and Suggestions.—An operator who is continually changing settings and complaining about design features probably never will become proficient because he does not feel relaxed and confident on the machine.

Controls.—As an operator becomes proficient, he will operate several backhoe controls at one time, even though only one portion of the backhoe may be responding (fig. 7). The operator will move his hands as if he is playing a piano. All operators develop their own style for using the controls.

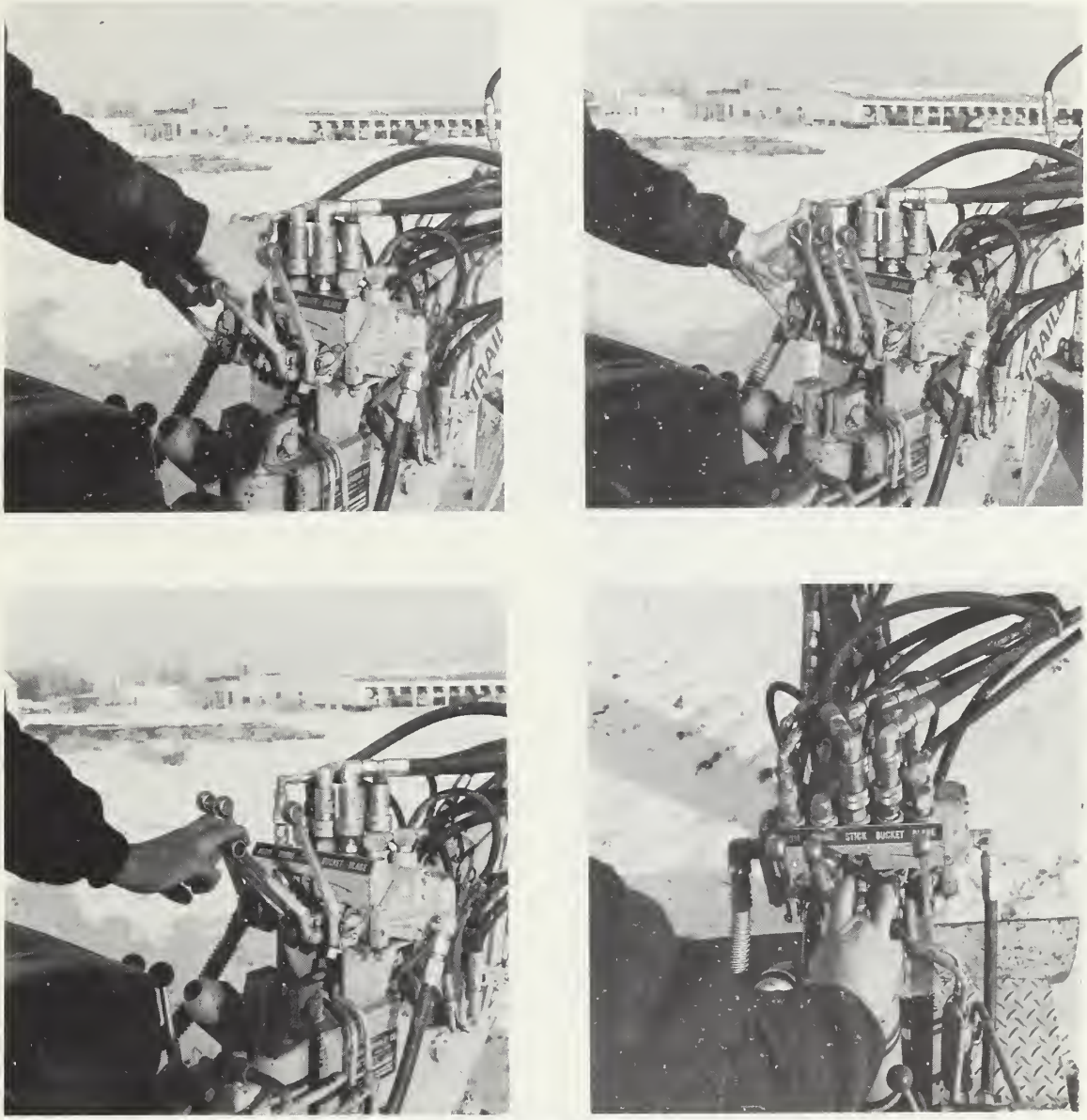

Figure 7. — Typical hand positions on backhoe controls.

Excavation Quantities and Tread Width.—Inexperienced operators move excessive quantities of material. A good operator will tend to move smaller quantities of materials as he becomes more experienced. The operator tends to keep the machine closer to the surface with each succeeding week of operation. This minimizes disturbance to the landscape by limiting the quantity of materials disturbed.

Lax Attitude Toward Maintenance.—An operator who does not service the machine properly should be replaced. Improper maintenance will lead to excessive wear and breakdowns.

Operating Guidelines

In normal operation, the backhoe is used to remove rocks, stumps, roots, and brush, and to loosen and remove soil until the blade can be used effectively. Because of its size and tractive limits, the machine should not be used as a dozer for loosening soil. The blade can be used to move earth and rock, but the material must be relatively loose.

A trainee should never operate the Trailblazer at more than 50 percent throttle during the first 10 hours of operation. Often, experienced operators reduce the throttle setting for moving large objects, negotiating steep slopes, etc.

Operators should try to work the backhoe in front of the machine, rather than to the side. Avoid moving large fixed objects that are beside the machine. Maneuver the machine to keep the work in front as much as possible.

When continual use of the hydraulic drive is required, such as driving the machine to a construction site, it may be necessary to stop the machine at intervals and circulate the hydraulic oil through the backhoe system for cooling.

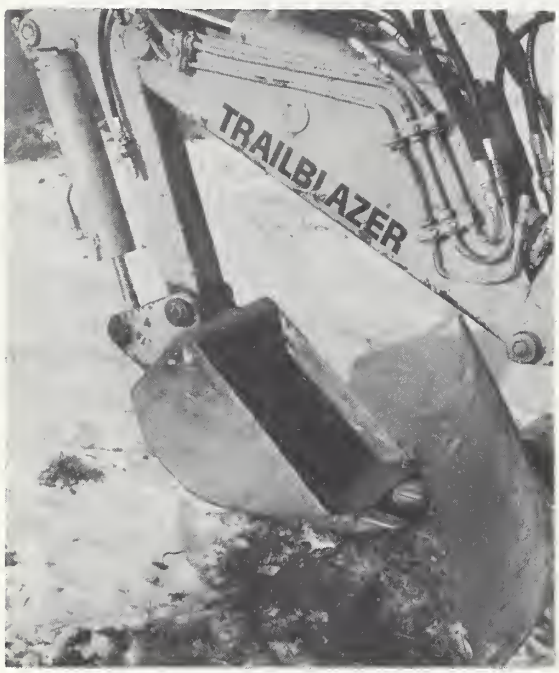

Figure 8. – Bucket teeth hooked under blade.

When moving up steep slopes, the backhoe can be very useful. By extending and anchoring the bucket, and pulling the machine towards the bucket, mobility is increased. This same procedure can be used to negotiate boggy areas. When moving over patches of rocks, around boulders too large to move, or on uneven ground, the backhoe can be positioned to act as a counterweight.

When moving down steep slopes, the bucket can be dropped on the ground to stabilize the machine.

The backhoe, swung and stopped abruptly, will retain enough momentum to move the Trailblazer slightly in the direction of the boom swing. Experienced operators will shift the machine slightly right or left by using the boom rather than the conventional steering controls. Shifting the machine by using momentum should not be attempted by beginners.

The dozer can be used to stabilize the backhoe. It should be forced down on the trail tread before the backhoe is used. The operator must avoid getting the teeth of the bucket under the blade. Raising the bucket with the teeth under the blade will cause the blade tilt pin to fail in tension(fig.8).

The backhoe is used to do most of the work, and a skilled operator is needed to use it effectively. Of the four controls for the system, only the swing control is difficult to master. An operator who has trouble becoming proficient in operating the swing controls may adjust the flow control valves located in the hydraulic supply lines to the swing cylinders. Closing the valves (turning clockwise) reduces the flow rate of the swing (fig. 9).

Inexperienced operators tend to operate the swing of the backhoe too fast and too jerkily. This can be corrected by properly "feathering" the controls. The swing is feathered by having the boom control open when the swing control is closed. This will prevent jerky motion at the end of the swing.

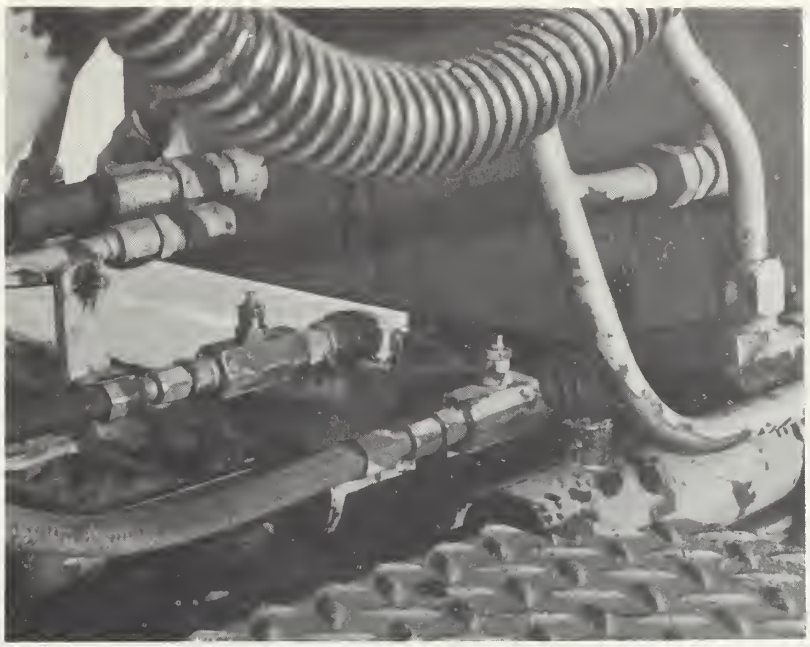

Figure 9. — Flow valves to control rate of boom swing.

Boom and swing control levers are worked with the fingers of the left hand. The stick, bucket, and dozer control levers are worked with the fingers of the right hand. Each control lever is labeled (fig.7). As skill improves, all backhoe control levers may be engaged at one time. Operators should learn to operate the control levers in a manner that suits them. For smooth operation, more than one control lever at a time must be operated.

Boulders the size and weight of the Trailblazer can be moved with little difficulty, especially if they are located on sideslopes. Large boulders are not moved by lifting. The ground around and under the lower side of the boulder is excavated. The boulder is then pried toward or away from the machine (using the dozer as a fulcrum for the bucket) and rolled to the side. It is usually cheaper to move a rock than to blast it.

Trees between 3 and 8 inches in diameter at stump height should be cut 2 to 2½ feet above the ground so the operator can use the additional height as a lever to tip the stump over. Trees smaller than 3 inches should be cut approximately 10 inches above the ground because the trunk is not stiff enough to be used as a lever. These small stumps are removed by pulling at the base with the backhoe. Stumps larger than 8 inches would be removed by blasting.

Brushy areas can be cleared without special techniques. When the brush has been cut, the root clumps are clearly visible and can easily be removed with the backhoe.

A switchback can be constructed much easier when working downhill because the blade can push material downhill more easily than uphill. If construction is progressing uphill, a temporary trail can be made to get the Trailblazer on the upper end of the switchback. The machine can be turned around to build the switchback downhill. An alternative is to construct switchbacks on the way out from the job.

Operating on a steep sideslope does not noticeably reduce production rates, but more material must be moved. However, skilled operators can minimize backhoe motion because material tends to roll downhill. Trail standards require 24 inches of full bench, so the track system of the Trailblazer can be used as a measuring gage. The tracks should be kept on cut materials.

A pushbutton located on the right side of the operator's seat is used to activate the electric winch.

The manufacturer's recommendations for lubrication should be followed. Prudent operators will modify the schedule if local conditions warrant it. On the track system, there are 16 fittings for greasing the track roller bearings and two fittings for greasing the drive-sprocket bearings. Eight of these fittings are on the inside of the tracks, so the machine should be positioned as shown in Figure 10 for easy access.

Figure 10. — Position for greasing roller bearings on inside of track.

The backhoe has nine grease fittings that should be greased daily. All nine fittings are accessible when the backhoe is positioned as shown in Figure 11. With the bucket fully extended, the stick partially extended, and the boom partially raised, the grease fitting located on the lower end of the boom cylinder easily can be reached from the bottom side.

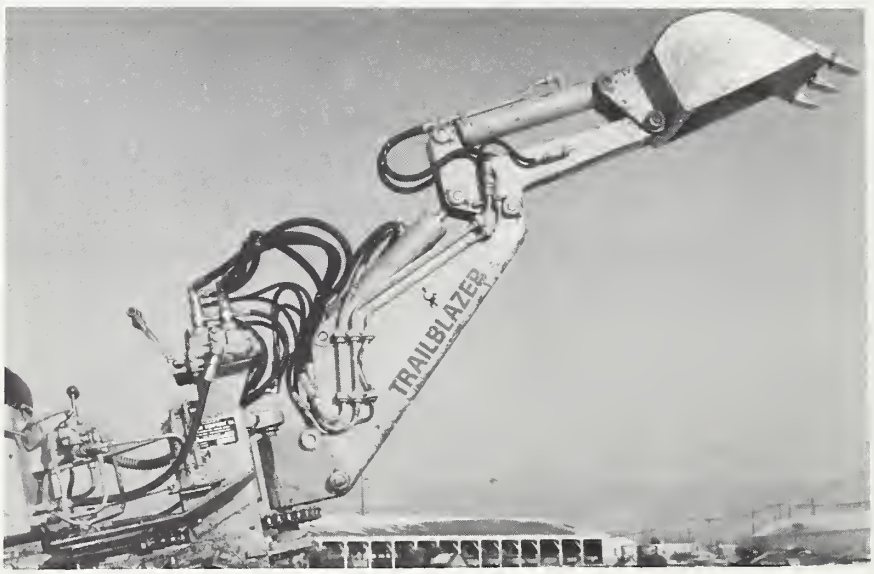

Figure 11. — Backhoe and dozer positions for greasing backhoe system.

Raising the machine with the dozer blade improves access for grease fittings above the dozer blade.

The Trailblazer consumes fuel at an average rate of .67 gallons per hour. Under varying conditions, fuel consumption ranges from .93 to .58 gallons per hour. The fuel tank holds 4 gallons.

During the 142-hour test at Wrangle Creek, routine maintenance, as recommended by the manufacturer, required 8 hours and 50 minutes. In addition to this time, 19 hours and 45 minutes were required to repair broken components. Routine maintenance and repairs averaged 1.05 hours per day. A significant portion of the repair time was for travel. Table 5 shows maintenance items, the frequency of each, and the total time required to repair or maintain the item.

Table 5.–Maintenance and repair of Trailblazer during Wrangle Creek evaluations

Item	Frequency	Total Time Required
Refuel engine	27	2 hours 15 minutes
Grease entire machine (includes backhoe)	15	3 hours 45 minutes
Grease backhoe only	19	2 hours 50 minutes
Repair sheared drive motor keys	4	3 hours 25 minutes
Tighten dozer center pivot bolt	4	1 hour
Replace bearing on track	1	4 hours 20 minutes
Replace hydraulic hose to drive motor	2	4 hours 20 minutes
Replace hose on backhoe	1	1 hour
Replace cotter pin in track master link	4	2 hours 25 minutes
Dozer arm pivot pin (key replaced)	1	0 hour 10 minutes
Travel time to base camp for parts		3 hours 5 minutes
TOTAL TIME		28 hours 35 minutes

The set screws through the inner bearing race hub on the track roller bearings could not be kept tight. It was finally decided to leave the set screws loose and to frequently inspect the roller bearings and shafts. There was no visible damage to either the bearings or shafts. Since the shafts are welded to the track rollers, the set screws only serve to keep the shafts from turning in the inner races of the bearings. Therefore, keeping the set screws tight is not considered important.

Figure 12. – Proper track tension on firm, level ground.

Track tension is briefly mentioned in the operator's manual. This is a very important item and must not be neglected. The manufacturer's representative recommends that track tension be checked with the machine standing on a firm surface. The center of the track should rise to within 1 inch of the bottom of the hydraulic oil reservoir (fig. 12). Operating with the tracks too tight will cause excessive wear, consume valuable torque, and increase component failures in the track system. Once track tension is properly set, only periodic adjustment is necessary.

DISCUSSION

During the test period, the Trailblazer was never tipped over. At no time did the operator feel he was in a hazardous position. An experienced operator can sense a dangerous condition, and by simple maneuvers such as dropping the bucket, repositioning the machine, driving the blade further into the trail tread, or placing more material under the downslope track, can correct the condition. Poor judgment is the major cause of accidents. Figure 13 shows the machine at work contouring a steep slope. Figure 14 shows some trail built by the Trailblazer.

Figure 13. — Trail under construction with backhoe.

Figure 14. — Trail constructed by Trailblazer.

As a result of the tests conducted, guidelines were established for selection and training of operators. Consideration was also given during the tests to maintenance items requiring special attention.

When the machine is on a sideslope, it is natural for the operator to move to the high side of the machine. From the high side, the operator would have no problem escaping on the uphill side. Operators should be warned never to put a foot down to attempt to prevent a tip-over. The operator should jump off the high side of the Trailblazer when he feels the machine is tipping. A warning decal should be placed on each Forest Service Trailblazer to insure that operators are aware of proper escape procedure.

During the test, the operator negotiated the Trailblazer around the base of a large tree on a 40 percent sideslope. In this case, the backhoe was swung uphill and used as a counterweight.

The production rates shown in this report are conservative because of bad weather during the test. Rain fell during the entire test, and the crew was continually fighting mud. The trail tread became

very rutted from scooter travel. Since the crew had never worked with the machine, production could increase with experience.

Appendix B contains a recommended list of spare parts and tools.

CONCLUSIONS

The Morrison Trailblazer holds great promise for building Forest Service trails. In the test held by this Center, costs of building trail with the Trailblazer were 50 percent below estimates based on hand labor. In Region 6, where the Trailblazer has been used by private contractors, similar cost reductions have been made.

Operators must be carefully selected and trained. Construction costs will be determined by the skill of the operator and proper maintenance of the machine.

APPENDIX A

Hourly Rate Analysis of Trailblazer

Depreciation	10-Year Life	7-Year Life
Initial cost of machine	$5,200	$5,200
Depreciation schedule	10 years	7 years
Salvage value	$ 312	$ 520
Annual depreciation	$ 489	$ 669
Use Period		
Six months per year x 21 days per month x 5.2 production hours per day	6,552 hours	4,586 hours
Hourly Costs		
Depreciation	0.79	1.13
Fuel	0.21	0.21
Oil	0.025	0.025
Grease	0.045	0.045
Hydraulic oil	0.10	0.10
Hydrostatic repair	1.00	1.00
Hose repair	0.045	0.045
Cylinder repair	0.04	0.04
Pump repair	0.05	0.05
Engine repair	0.04	0.04
Track repair	0.345	0.345
Backhoe system	0.02	0.02
Miscellaneous repair items	0.05	0.05
Repair labor	0.50	0.50
Equipment Management Overhead	0.66	0.72
TOTAL HOURLY RATE	3.92	4.32

APPENDIX B

Spare Parts and Tools

The following items should accompany the Trailblazer during field operation:

1. Small assortment of hand tools, small set of Allen wrenches, 3/8-socket set to 1 inch, hammer, screwdrivers (small and medium), sparkplug wrench, adjustable hand wrenches (6-, 8-, and 10-inch), drive punch, pliers, ignition points file and adjusting wrench.
2. 1 each—master link for joining track No. 120 roller chain.
3. 1 each—box of cotter pins for track roller chain links.
4. 1 each—bearing for drive motor sprocket. This bearing should have a 4-hole mounting; however, it can be used as a substitute for a track roller bearing by using two diagonal holes for mounting.
5. 6 each—woodruff keys 1/4 x 1.
6. 6 each—grease fittings to screw into a 1/8 npt.
7. 6 each—links of No. 80 roller chain (cotter pin type) for swing chain repair.
8. 1 each—set of ignition breaker-points for engine.
9. 24 each—Allen wrenches (1/8-inch) for tightening track roller bearing collar set screws.
10. Small assortment of bolts, nuts, washers and machine screws.